which forms a large part of the chapter dealing with "the mechanism of life."

The author claims for his work, that it is essentially an exposition of ' cellular physiology." I am myself inclined to think that he exaggerates the value of this point of view. The idea of the cell, important as it has been, and still is, when we deal with the cell as a morphological unit, seems to me of much less importance when we deal with it as a physiological unit. But I pass this over, in order to join issue with the author on two other matters. He speaks "of the impotence of the physiology of to-day, when brought to face the simplest processes of life," and writes as if all the knowledge which, especially during the last thirty years, has been gained by the application of exact physical and chemical methods to the study of the phenomena of life, simply led to the end of a blind alley. He urges that, while we are rapidly approaching perfection in these things, we yet are impotent in face of the deeper problems. He even goes very near repeating the taunt of the Philistine, "With all your boasted progress, you are still unable to tell us *what life is*," with, however, the difference that he uses the taunt in order to incite physiologists to adopt other methods of inquiry. I venture to think that in this the author is quite wrong. Not only has the progress of physiology, due to the use of exact methods, been remarkable during the last half-century or so, but also by those methods we have been drawn measurably nearer the inner and hidden mysteries. To take one instance among many, the application of exact physical methods to the study of muscles, so far from having brought us to a point beyond which we cannot go, seems just now to be opening up the way to fruitful conceptions of the intimate nature of muscular contraction—conceptions which would have been impossible in the absence of the knowledge gained by the graphic method. Two armies, from two different sides—one physical, the other chemical—are attacking that difficult—to some it seems impregnable—fortress. They have already gained many of the outworks; they are pressing on, drawing nearer to each other; and when they touch hands, they will do that which will put to shame all scoffs at their impotence.

Then again, the author finds fault with the preponderant attention given by physiologists to the study of the higher vertebrate animals; he blames them for their comparative neglect of the lower and, especially, of the lowest invertebrate forms. It is not for me, who in my rash youth had wild dreams of building up a new physiology by beginning with the study of the amœba, and working upwards, to say one word against the experimental investigation of the lower forms of life. But experience and reflection have shown me that, after all, the physiological world is wise in spending its strength on the study of the higher animals. And for the simple reason that in these, everything being so much more highly differentiated, the clues of the tangles come, so to speak, much more often to the surface, and may be picked up much more readily. Taking again, as an instance, the molecular processes which give rise to the movements of animals, and which appear under such forms as that of amœboid movement, and that of the contraction of a striated muscle, I venture to think that the very apparent simplicity of the former is an obstacle to our getting a real grasp of its inner nature, and that by our studies of the complex muscle, we are drawing nearer to such a grasp than we could ever have done by observations confined to the phenomena of the amœba itself. And so in many other instances. The study of the lower forms of life is, in reality, more difficult than that of the higher forms; and the latter naturally comes first. At the same time the author will have the sympathy of all, if his contention be limited to the assertion that the full fruition of physiological truth can only be reached by the careful study of all forms of life, whether high or low; this, indeed, his own special investigations have already shown, and in this sense the contribution to a "general physiology," which his present volume offers, is gladly welcomed by us all. M. Foster.

NERNST'S THEORETICAL CHEMISTRY.

Theoretical Chemistry, from the Standpoint of Avogadro's Rule, and Thermodynamics. By Prof. Walter Nernst, Ph.D. of the University of Göttingen. Translated by Prof. Charles Skeele Palmer, Ph.D. of the University of Colorado. Pp. xxv.–697. (London: Macmillan and Co. 1895.)

No one can compare the knowledge we possess to-day of the conditions and general laws of chemical change with the state of our knowledge ten years ago, without being much impressed by the enormous advances made in the last decade. Accurate and generalised knowledge of physical chemistry did not exist ten or twelve years ago. What is practically a new science has arisen, based on the work of such men as Guldberg and Waage, van't Hoff, Ostwald, Arrhenius, Nernst, Raoult, Gibbs, and Thomsen, who built upon the foundations laid by Dalton, Avogadro, Berthollet, Faraday, Helmholtz, Thomson, and Clausius. The special mark of the new science is that it has been produced, to use the words of Nernst, "by the co-operation of two sciences which hitherto have been, on the whole, quite independent of each other." One hardly knows whether to speak of *physical chemistry* or *chemical physics*.

The text-book of this new science is Ostwald's "Lehrbuch der Allgemeinen Chemie." Notwithstanding the thoroughly satisfactory character of that work, there was room for another book which should treat the subject in less full detail, and which should pay especial attention to the data and the conceptions that have been systematised and applied in a general way. Prof. Nernst has written exactly the book that was wanted; and this book now appears in a form which brings it within the reach of all English-speaking students.

The *Theoretical Chemistry* of Prof. Nernst deals with (1) the universal properties of matter, (2) the atom and the molecule, (3) the transformations of matter, and (4) the transformations of energy. The first section treats of (1) the gaseous, (2) the liquid, (3) the solid, state of aggregation, (4) the physical mixture, and (5) dilute solutions. The second section is devoted to (1) the atomic theory, (2) the kinetic theory of the molecule, (3) the determination of molecular weight, (4) the constitution of the molecule, (5) physical properties and molecular structure, (6) the dissociation of gases,

(7) electrolytic dissociation, (8) the physical properties of salt solutions, (9) colloidal solutions, and (10) the absolute size of molecules. Sections three and four are concerned with the subject of affinity. The author treats that part of this subject which is connected with the transformations of matter under the headings: (1) the law of chemical mass-action, (2) chemical statics in (*a*) homogeneous, and (*b*) heterogeneous systems, (3) chemical equilibrium in salt solutions, and (4) chemical kinetics. In dealing with the energetics of chemical affinity, Prof. Nernst treats of (1) the applications of the first law of heat, (2) temperature and (*a*) complete, (*b*) incomplete, chemical equilibrium, (3) temperature and the velocity of reactions, (4) heat and chemical energy, (5) electrochemistry, (6) photochemistry. An appendix contains accounts of the more important developments of theoretical chemistry in the year 1893.

The ground covered by the book is evidently very large, and very different from that traversed by the books on theoretical chemistry published ten years ago.

Theoretical chemistry, as understood by Nernst, is based on Avogadro's law, and van't Hoff's extension of that law to dilute solutions, the law of mass-action, and the laws of thermodynamics. It would not be very far from the truth to say that the book is concerned with the meaning of the sign of equality in chemical equations, and that the connotation of that sign is elucidated by applications of the laws of Avogadro and van't Hoff, and the law of mass-action, bound together and lighted up by the laws of thermodynamics.

The essential characteristics of the book, so far as I can judge, are the exceeding clearness in the statement of each problem of theoretical chemistry, the cutting out of irrelevant issues, and then the binding together of the apparently detached discussions into an harmonious whole by the application of the general principles of the molecular-atomic theory, and of chemical energetics.

The treatment of *osmotic pressure* may be chosen as an illustration of these characteristics of Prof. Nernst's book. The meaning of the term *osmotic pressure* is made clear on pp. 118–119, by the description of a theoretical experiment on the diffusion of sugar in aqueous solution through a semi-permeable partition fitted with a movable piston. Unfortunately, the translator has rendered *Lösungsmittel* by "solvent material"; had he used the term "solvent" (as he does in some other passages), the meaning would have been better conveyed. Then follow lucid paragraphs on the methods of measuring osmotic pressure (I wish the translator had not allowed the phrase to pass, "ether containing considerable benzene"), admirably illustrating the bearings on this problem of determinations of vapour-pressures, boiling points, and freezing points. Having thus, by adhering strictly to the problem under discussion, arrived at a clear conception of osmotic pressure, the author proceeds, in a few brief and clear paragraphs, to consider the circumstances which condition the osmotic pressures of solutions, viz. the concentration of the solution, the temperature, the nature of the dissolved substance, and the nature of the solvent. The outcome of the matter is then summed up in the statement—*the lowering of the freezing point of a dilute solution is proportional to the number of molecules of the dissolved substance*. This summary at once suggests an inquiry into the range of applicability of the law of osmotic pressure, and the laws of solution in general; and the inquiry leads to a statement of van't Hoff's extension of the law of Avogadro. The experimental determination of molecular weights by the application of the van't Hoff generalisation is described (pp. 224–231) in that part of the book which deals with the determination of molecular weights. When the author comes to treat of dissociation he returns to the subject of osmotic pressure, and shows how an application of the hypothesis of dissociation to salts in dilute aqueous solutions leads to a far-reaching theory of chemical change, and he propounds this theory in a clear and practical manner. In one of the chapters dealing with thermochemistry (pp. 565–567), the author, following van't Hoff, brings the subjects of osmotic pressure and electrolytic dissociation within the range of thermodynamical methods, and, by a fundamental equation, connects the equilibrium of a chemical system with such conditions as temperature, pressure, and dissociation. Had Prof. Nernst been tempted to discuss such a side issue as the part played by the solvent in bringing about electrolytic dissociation, he could not have arrived at the very general results to which his strictly accurate and limited method of inquiry have led him. He does, indeed, devote a paragraph or two to this matter of the action of the solvent (*e.g.* pp. 232, 444). He is careful to note the great interest and importance of the question; at the same time he draws attention to the fact, often overlooked, that no definite answer can be given to questions regarding the existence of compounds of molecules of the solvent with molecules of the dissolved substance by the study of the osmotic pressures of dilute solutions, because the existence of such compounds would not affect the osmotic pressures of fairly dilute solutions.

Prof. Nernst dismisses the so-called *hydrate theory of solution* in a short and somewhat contemptuous paragraph (p. 444); he speaks of this conception as having no theoretical basis, as having led to no general laws, and as based on an uncritical examination of experimental data.

A very admirable feature of the book is the care taken to warn the student against drawing unsound and inapplicable deductions from sound generalisations. For instance, at the beginning of the chapter on the physical properties of salt solutions (p. 331), the statement is enunciated that *the properties of an aqueous solution of a salt are made up, additively, of the properties of the free ions*. And then the illegitimate and misleading inferences which may be, and some of which have been, deduced from this generalisation are noted in a few sentences, before the true meaning and applicability of the statement are developed.

I should like to deal at length with the author's treatment of the law of mass-action, and the many applications and developments of this law; but space forbids. Among the applications of the law of mass-action I would ask the student to note that which serves to explain the discrepancies among the values for the *strengths* of acids obtained by Ostwald by employing different methods of measurement (p. 438).

The volume literally abounds in suggestions; new light is thrown on almost every question of theoretical chemistry. When this book becomes generally known and studied by English chemists, it seems to me it will be impossible for any of them to refuse to acknowledge the marvellous advances which have been made in the science by the introduction of the conception of electrolytic dissociation.

I would recommend every student of advanced chemistry to study this work. Merely to glance through it is little use: it must be studied laboriously; and it will well repay the labour. Of course there are weak parts in the book. I think the treatment of *the constitution of the molecule* is too sketchy; and chapter vi. of Book iv., on *electrochemistry*, should, in my opinion, have been either expanded or omitted.

Of the translation it is difficult to speak advisedly. I think the translator has attempted an impossible task, the task, namely, of literally changing German into English. If the meaning of sentences in one language is to be conveyed in another language, it seems to me that a paraphrase, not a so-called literal translation, is needed. The task of translation must have been extremely difficult; the subject-matter is complicated, and German is not a language distinguished by its lucidity. The meaning of the original is conveyed on the whole; but the sentences read strangely. See, for instance, the most peculiar sentence near the bottom of page 591. There is an extraordinary sentence about plucking fruit from stepping-stones, on p. 354. Several cases of absolute mistranslation are to be found; for instance, the sentence in italics in the ninth and tenth lines from the bottom of p. 254, and the sentence at the beginning of Book iii., p. 353. *Beliebig* is sometimes translated "casual," sometimes "selected."

I admit the great difficulty of the task undertaken by the translator: as I have said, he has generally succeeded in conveying the meaning of the original; but I think the rendering into English might have been at once more accurate, more elegant, and more readable.

M. M. Pattison Muir.

OUR BOOK SHELF.

Bird Notes. By the late Jane Mary Hayward. Edited by Emma Hubbard. Pp. 181. (London: Longmans, Green, and Co. 1895.)

Catalogue of the Birds of Prey (Accipitres and Striges). By J. H. Gurney, F.Z.S. Pp. 56. (London: R. H. Porter, 1894.)

A dainty book is Miss Hayward's, the pretty little process-blocks, representing a number of our common birds, matching the short sketches of avian habits. The lamented author had a "deep-rooted love of the beauty of the world." She was a close and unwearied watcher of bird traits, and her notes possess the charm of all original observations. From a scientific point of view, the chief failing of many of the notes is that they endow the birds too largely with human consciousness. Mrs. Hubbard recognises the objection, and says something in favour of this "anthropomorphism"; but while such fancies are poetically attractive, and may be psychologically justifiable, they must always be of less value than the facts which give them birth.

The ornithological papers of the late Mr. J. H Gurney were both numerous and important, and in the volume under notice we have further evidence that the son worthily carries on his father's interest in the collection at Norwich Museum. All the birds of prey (hawks and owls) in the Museum were catalogued by Mr. J. Reeve, the veteran custodian, and from this MS. catalogue, and his father's "List of Diurnal Birds of Prey," Mr. Gurney has compiled the list of Accipitres and Striges. According to the list of the former order, the total number of existing species of diurnal birds of prey is now 470, of which at least 89 are only sub-species. The total number of existing species of owls is placed at 268, of which 87 appear to be only sub-species.

Before each bird's name, in the two lists, a letter is placed to mark the zoological region to which it belongs, on Mr. Sclater's classification. A striking testimony to the efficiency of this system is given by Mr. Gurney, in the following words: "The way in which these several divisions [Mr. Sclater's] are justified by the Birds of Prey, and especially by the Diurnal Birds of Prey, is remarkable, and if they were to be decided afresh by that class of birds alone they could not very well be improved upon. Seven-eighths of the Raptores are found in one region only—*i.e.* not in more than one; and the region which has the greatest number is the Neotropical or South-American region, which contains 181 Hawks and Owls."

The whole of the Raptorial collection of Norwich Museum is now being transferred to Norwich Castle; and the completeness of the collection can be judged from the fact that it comprises 403 out of the total of 470 accepted species and sub-species of Accipitres, and 195 out of 268 known species and sub-species of the order of Striges. Mr. Gurney may well be proud of the collection, and of the fine Castle Museum in which it is housed.

Prince Henry the Navigator. By C. Raymond Beazley, M.A., F.R.G.S. (Heroes of the Nations Series.) (Putnam's Sons).

In this most interesting and valuable book, Mr. Beazley shows us clearly the growth of geographical knowledge, carrying his researches back earlier even than 130 A.D., he tells us that the first maps and charts of the old world are due to Eratosthenes and Strabo. Ptolemy succeeded them, improved their work, and, where knowledge failed him, made errors himself; the author writes thus of his great chart: "Never was there a clearer outrunning of knowledge by theory, science by conjecture, than in Ptolemy's scheme of the world (*c.* A.D. 130)."

We gather much information concerning Greek and Arabic geographers, of the early Christian pilgrims, and of the discoveries of the Norsemen. Throughout the book, we watch, as it were, the growth and improvements of the maps and charts. We see the expansion of geography due to the crusades and land travel. Finally we are brought to Prince Henry the Navigator himself. From youth upwards, retired and studious, he withdrew himself at the age of twenty-one to his Naval Arsenal at Sagres, and devoted the rest of his life to the accomplishment of his three chief objects—"to discover, to add to the greatness and wealth of Portugal, and to spread the Christian faith." We can but marvel at this great man, at the untiring energy with which he worked, but still more at the greatness of that work.

Mr. Beazley has treated the subject in a very thorough and interesting manner, and the numerous maps form a most important part of the book; they date from 130 A.D.–1492. No pains have been spared to make the subject quite clear to the student. All through the book we see how the dominion of the sea has been continuously enlarged by the perpetual application of science to the art of navigation.

W.